

Customer No.: 31561
Application No.: 10/063,574
Docket NO.: 8382-US-PA

REMARKS

1. Present Status of the Application

Claims 1, 18, 35, 54, 73, 94 are rejected under 35 U.S.C. 102(a) as being anticipated by Admitted Prior Art (APA), figures 1-7. Claims 2, 19, 36, 55, 74, 95, 3, 20, 37, 56, 75, 96, 14, 31, 48, 67, 86, 107, 16, 33, 50, 69, 88, 109, 17, 34, 51-53, 70- 72, 89-93, 110-112 are rejected under 35 U.S.C 103(a) as being unpatentable over APA in view of Datta et al. (US Patent No. 5,486,282). Claims 4, 21, 38, 57, 76, 97, 5, 22, 39, 58, 77, 98, 6, 23, 40, 59, 78, 99 are rejected under 35 U.S.C 103(a) as being unpatentable over APA in view of Yung et al. (US Patent No. 5,162,257). Claims 7, 24, 41, 60, 79, 100, 8, 25, 42, 61, 80, 101, 9, 26, 43, 62, 81, 102, 13, 30, 47, 66, 85, 106 are rejected under 35 U.S.C 103(a) as being unpatentable over APA in view of Baker et al. (US Patent No. 5,508,229). Claims 10, 28, 45, 64, 83, 104, 11, 28, 45, 64, 83, 104, 12, 29, 46, 65, 84, 105 are rejected under 35 U.S.C 103(a) as being unpatentable over APA in view of Baker et al. (US Patent No. 5,508,229). Upon this response, claims 1-112 remain pending in the present application.

2. Response To Objections/Rejections

Applicants respectfully traverse the rejections for at least the reasons set forth below.

Response To Claim Rejections Under 35 U.S.C. Section 102

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As originally recited, independent claims 1, 18, 35, 54, 73, 94 respectively recite below:

1. A method of forming bumps on a silicon wafer having an active surface with a passivation layer and a plurality of bonding pads thereon such that the passivation layer exposes the bonding pads, the method comprising the steps of:

forming an adhesion layer over the active surface of the wafer, the adhesion layer covering both the bonding pads and the passivation layer;

forming a barrier layer over the adhesion layer;

forming a wettable layer over the barrier layer;

conducting a first photolithography process to form a plurality of photoresist blocks on the wettable layer;

conducting a first etching operation to remove the wettable layer and the barrier layer so that only the residual wettable layer and barrier layer underneath the photoresist blocks remain;

after conducting the first etching operation, removing the photoresist blocks;

after removing the photoresist blocks, conducting a second photolithography process to form a photoresist layer over the adhesion layer, wherein the photoresist layer has a plurality of openings that expose the wettable layer and the adhesion layer around the barrier layer;

after conducting the second photolithography process, *conducting a metal-filling operation* to form a solder material inside the openings of the photoresist layer, wherein the solder material covers the wettable layer and the adhesion layer around the barrier layer;

after conducting the metal-filling operation, removing the photoresist layer;

after removing the photoresist layer, conducting a first reflow operation to transform the solder material into a plurality of solder balls having a hemispherical profile, and the solder balls retracting onto the upper surface of the wettable layer without extending onto the adhesion layer;

after conducting the first reflow operation, *conducting a second etching operation to remove a portion of the adhesion layer* so that only residual adhesion layer underneath the barrier layer is retained and the passivation layer on the wafer is exposed to the outside; and

conducting a second reflow operation.

18. A method of forming bumps on a silicon wafer having an active surface with a passivation layer and a plurality of bonding pads thereon such that the passivation layer exposes the bonding pads, the method comprising the steps of:

forming an adhesion layer over the active surface of the wafer, the adhesion layer covering both the bonding pads and the passivation layer;

forming a barrier layer over the adhesion layer;

forming a wettable layer over the barrier layer;

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conducting a first photolithography process to form a plurality of photoresist blocks on the wettable layer;

conducting a first etching operation to remove the wettable layer and the barrier layer so that only the residual wettable layer and barrier layer underneath the photoresist blocks remain;

after conducting the first etching operation, removing the photoresist blocks;

after removing the photoresist blocks, conducting a second photolithography process to form a photoresist layer over the adhesion layer, wherein the photoresist layer has a plurality of openings that expose the wettable layer and the adhesion layer around the barrier layer;

after conducting the second photolithography process, *conducting a metal-filling operation* to form a solder material inside the openings of the photoresist layer, wherein the solder material covers the wettable layer and the adhesion layer around the barrier layer;

after conducting the metal-filling operation, conducting a first reflow operation to transform the solder material into a plurality of solder balls having a hemispherical profile, and the solder balls retracting onto the upper surface of the wettable layer without extending onto into the adhesion layer;

after conducting the first reflow operation, removing the photoresist layer;

after removing the photoresist layer, *conducting a second etching operation to remove a portion of the adhesion layer* so that only residual adhesion layer underneath the barrier layer is retained and the passivation layer on the wafer is exposed to the outside; and

conducting a second reflow operation.

35. A method of forming bumps over a ~~silicon~~ wafer having an active surface thereon, the method comprising the steps of:

forming a first under-ball metallic layer over the active surface of the wafer;

forming a second under-ball metallic layer over the first under-ball metallic layer;

conducting a first photolithography process to form a plurality of photoresist blocks over the second under-ball metallic layer;

conducting a first etching operation to remove the second under-ball metallic layer so that only the second under-ball metallic layer underneath the photoresist blocks remains;

after conducting the first etching operation, removing the photoresist blocks;

after removing the photoresist blocks, conducting a second photolithography process to form a photoresist layer over the first under-ball layer, wherein the photoresist layer has a plurality of openings that expose the second under-ball metallic layer;

after conducting the second photolithography process, *conducting a metal-filling operation* to fill a solder material into the openings of the photoresist layer, the solder material covering the second under-ball metallic layer;

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after conducting the metal-filling operation, removing the photoresist layer;
after removing the photoresist layer, conducting a first reflow operation to transform the solder material into a plurality of solder balls; and
after conducting the first reflow operation, *conducting a second etching operation to remove a portion of the first under-ball metallic layer* so that only the first under-ball metallic layer underneath the second under-ball metallic layer remains.

54. A method of forming bumps over a wafer having an active surface thereon, the method comprising the steps of:
forming a first under-ball metallic layer over the active surface of the wafer;
forming a second under-ball metallic layer over the first under-ball metallic layer;
conducting a first photolithography process to form a plurality of photoresist blocks over the second under-ball metallic layer;
conducting a first etching operation to remove the second under-ball metallic layer so that only the second under-ball metallic layer underneath the photoresist blocks remains;
after conducting the first etching operation, removing the photoresist blocks;
after removing the photoresist blocks, conducting a second photolithography process to form a photoresist layer over the first under-ball layer, wherein the photoresist layer has a plurality of openings that expose the second under-ball metallic layer;
after conducting the second photolithography process, *conducting a metal-filling operation* to fill a solder material into the openings of the photoresist layer, the solder material covering the second under-ball metallic layer;
after conducting the metal-filling operation, conducting a first reflow operation to transform the solder material into a plurality of solder balls ;
after conducting the first reflow operation, removing the photoresist layer; and
after removing the photoresist layer, *conducting a second etching operation to remove a portion of the first under-ball metallic layer* so that only the first under-ball metallic layer underneath the second under-ball metallic layer remains.

73. A method of forming bumps over a wafer having an active surface thereon, the method comprising the steps of:
forming a first under-ball metallic layer over the active surface of the wafer;
forming a second under-ball metallic layer over the first under-ball metallic layer;
conducting a first photolithography process to form a plurality of photoresist blocks over the second under-ball metallic layer;
conducting a first etching operation to remove the second under-ball metallic layer so that only the second under-ball metallic layer underneath the photoresist blocks remains;
after conducting the first etching operation, removing the photoresist blocks;

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after removing the photoresist blocks, conducting a second photolithography process to form a photoresist layer over the first under-ball layer, wherein the photoresist layer has a plurality of openings that expose the second under-ball metallic layer;

after conducting the second photolithography process, **conducting a metal-filling operation** to fill a solder material into the openings of the photoresist layer, the solder material covering the second under-ball metallic layer;

after conducting the metal-filling operation, removing the photoresist layer;

after removing the photoresist layer, conducting a first reflow operation to transform the solder material into a plurality of solder balls; and

after conducting the first reflow operation, **conducting a second etching operation to remove a portion of the first under-ball metallic layer** so that only the first under-ball metallic layer underneath the second under-ball metallic layer remains.

94. A method of forming bumps over the active surface of a wafer, the method comprising the steps of:

forming a first under-ball metallic layer over the active surface of the wafer;

forming a second under-ball metallic layer over the first under-ball metallic layer;

removing a portion of the second under-ball metallic layer to expose the first under-ball metallic layer to the outside;

after removing a portion of the second under-ball metallic layer, forming a solder material over the second under-ball metallic layer;

after forming the solder material over the second under-ball metallic layer, conducting a first reflow operation; and

after conducting the first reflow operation, **removing a portion of the first under-ball metallic layer** so that the first under-ball metallic layer underneath the second under-ball metallic layer remains.

(emphasis added)

Applicants respectfully assert that the bump manufacturing method claimed in the present invention patentably distinguishes over figures 1-7 illustrated in Applicants' admitted prior art, because the admitted prior art fails to disclose these features emphasized above (in bold).

In the admitted prior art, after the solder material 160 is formed on the wettable layer 140, the wettable layer 140, the barrier layer 130 and the adhesion layer 120 in sequence are

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removed and remains underneath the solder block 160 (See FIGS 5-6). As a result, during etching, the etchant comes in contact with the solder material 160 and etches away a portion of the solder material 160. Hence, the overall thickness of the solder block 160 is reduced, leading to material wastage and difficulty in controlling the quality of the solder material 160. Furthermore, when the etchant for etching the wettable layer 140 and the barrier layer 130 is improperly prepared, the etchant may act on the solder material 160. The etchant may peel off the solder material 160 from the wettable layer 140 before the wettable layer 140 and the barrier layer 130 are removed. (From paragraph [0010])

However, in the present invention, after a portion of the second under-ball metallic layer, such as a barrier layer 330, 630 and a wettable layer 340, 640, is removed using, for example, an etching process, a solder material 370, 670 is formed over the second under-ball metallic layer. Thereafter, the exposed first under-ball metallic layer, such as an adhesion layer 320, 620, is removed using, for example, an etching process. As a result, a two-stage etching process is used to etch the under-ball metallic layer. During the first etching operation, that is, the etching of the wettable layer and the barrier layer, etchant will not etch the solder material because the solder material is not yet formed over the wettable layer. Etchant instead contacts the solder material only when the adhesion layer is etched in the second etching operation. Consequently, the period of contact of solder material with etchant is reduced and hence dimensional reduction of the solder material is minimized. (from paragraph [0049]) Therefore, Applicants consider that the subject matters claimed in the present invention can not be attained by figures 1-7 of the

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admitted prior art because the above-mentioned advantage of the present invention can not be achieved by the admitted prior art.

One of the characteristics, in accordance with the present invention, is that after a portion of the second under-ball metallic layer, such as a barrier layer and a wettable layer, is removed using, for example, an etching process, a solder material is formed over the second under-ball metallic layer. Thereafter, the exposed first under-ball metallic layer, such as an adhesion layer is removed using, for example, an etching process. The admitted prior art (APA) fails to teach, suggest, or hint the above feature. Therefore, Applicants respectfully traverse the rejection under 35 U.S.C. 102 (a).

Response To Claim Rejections Under 35 U.S.C. Section 103

Applicants respectfully assert that the bump manufacturing method claimed in the present invention patentably distinguishes over the disclosures by figures 1-7 illustrated in Applicants' admitted prior art, by Datta, by Yung and by Baker, because the disclosures fail to disclose these features emphasized in claims 1, 18, 35, 54, 73, 94 (in bold).

One of the features, in accordance with the present invention, is that after a portion of the second under-ball metallic layer, such as a barrier layer and a wettable layer, is removed using, for example, an etching process, a solder material is formed over the second under-ball metallic layer. Thereafter, the exposed first under-ball metallic layer, such as an adhesion layer is removed using, for example, an etching process. However, all of the disclosures by Applicants'

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admitted prior art, by Datta, by Yung and by Baker fail to teach, suggest or hint the above feature. Therefore, even though the disclosures by Applicants' admitted prior art is combined with Datta or Yung or Baker, the subject matters claimed in the present invention can not be attained.

Therefore, Applicants respectively submit that the subject matters claimed in the present invention can not be attained by combining the disclosures of the admitted prior art, with Datta, Yung or Baker.

For at least the foregoing reasons, Applicants respectfully submit that independent claims 1, 18, 35, 54, 73, and 94 patently define over the prior art references, and should be allowed. For at least the same reasons, dependent claims 2-17, 19-34, 36-53, 55-72, 74-93 and 95-112 patently define over the prior art as well.

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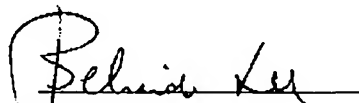
CONCLUSION

For at least the foregoing reasons, it is believed that the pending claims 1-112 are in proper condition for allowance. If the Examiner believes that a telephone conference would expedite the examination of the above-identified patent application, the Examiner is invited to call the undersigned.

Respectfully submitted,

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